

# Load Bearing Equipment for Bone and Muscle Project

Center Independent Research & Developments: JSC IRAD Program | Mission Support Directorate (MSD)



## ABSTRACT

Axial skeletal loads coupled with muscle torque forces around joints maintain bone. Astronauts working in pairs to exercise can provide high eccentric loads for each other that are most effective. A prototype of load bearing equipment that will allow astronauts to perform exercises using each other for counter force generation in a controlled fashion and provide eccentric overload is proposed. A frame and attachments that can be rapidly assembled for use and easily stored will demonstrate feasibility of a design that can be adapted for ISS testing and Orion use.



Astronauts of equal size in position for exercise.

## ANTICIPATED BENEFITS

### To NASA funded missions:

The equipment will benefit current development missions by providing a low mass alternative to current exercise hardware. This will lower the support hardware mass requirements that are calculated for mission and hardware planning and design.

### To NASA unfunded & planned missions:

Exploration missions will benefit from reduced mass and increased system reliability. The equipment will meet the medical requirements for resistance exercise for missions over 30 days duration.

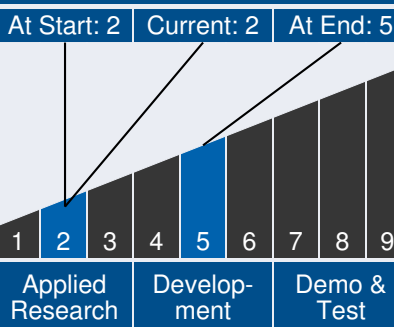
### To other government agencies:

The prototype device may be used to develop the hardware for proof on ISS as a countermeasure to bone and muscle loss. The equipment provides a way to load the body without acceleration dependent load fluctuations present in weight stack based equipment which the ARED simulates with the flywheel engaged. The flywheel introduces the same momentum hazards as weight stacks. Proponents of "impact" to preserve bone state that the acceleration generated spikes in

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## Technology Maturity



## Management Team

### Program Director:

- Douglas Terrier

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load are necessary. Microgravity is an excellent location for testing exercise theory, as all loads on the skeleton are induced by the specific exercises, allowing isolated testing of exercises and exercise methods. NIH would benefit from a comparison of ARED results on ISS to LBE results to determine whether load spikes benefit muscle and bone or are an unnecessary injury hazard.

## To the commercial space industry:

This prototype may be adapted to commercial space ventures in which occupancy of space craft by crews for over 30 days is planned.

## To the nation:

The exercise frame will advance space exploration by lowering mass and increasing reliability of equipment to maintain muscle and bone in space exploration missions. The equipment will illustrate the effectiveness of resistance exercise to prevent bone and muscle loss, both of which occur with aging. The equipment will also illustrate that effective exercise does not require expensive equipment with high mass and volume, and that partners exercising together at home can effectively supply the loads needed for musculoskeletal maintenance.

## DETAILED DESCRIPTION

Axial skeletal loads coupled with muscle torque forces maintain bone. Astronauts working in pairs to exercise can provide high eccentric loads for each other that are most effective. A prototype of load bearing equipment that will allow astronauts to perform exercises using each other for counter force generation in a controlled fashion and provide eccentric overload is proposed. A frame will be constructed to hold an astronaut back to back and shoulder to shoulder with his head at the other astronaut's lumbar or pelvic level. To exercise, one astronaut will allow his knees to flex when his feet receive high loads from the

### Management Team (cont.)

#### Program Executive:

- Douglas Terrier

#### Program Manager:

- Ronald G Clayton

#### Project Manager:

- Linda Shackelford

#### Principal Investigator:

- Linda Shackelford

### Technology Areas

#### Primary Technology Area:

Human Health, Life Support & Habitation Systems (TA 6)

#### Other Technology Areas:

- Materials, Structures, Mechanical Systems & Manufacturing (TA 12)

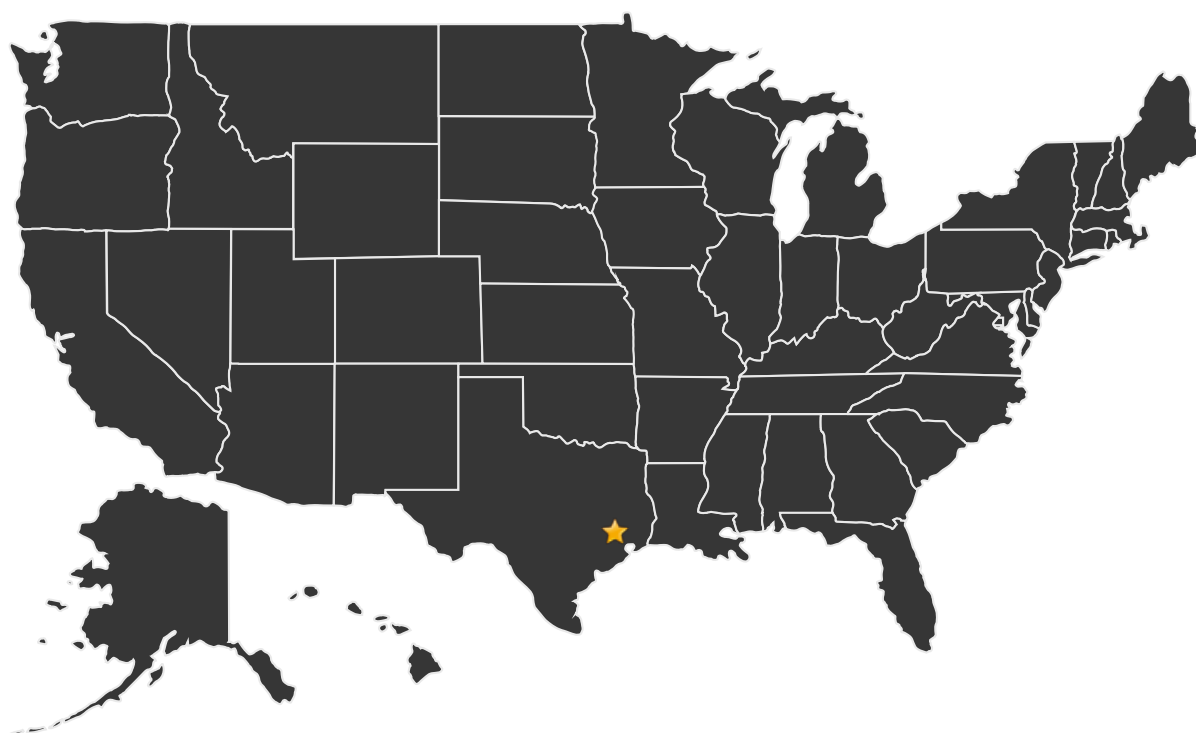
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feet of the other astronaut who fully extends his legs. Then the astronauts switch postures, each thereby performing a squat motion against the other astronaut's resistance. The frame will also serve to guide the tethers as they pass between the astronauts to connect the astronauts' right shoes and to connect the astronaut's left shoes. The frame will be constructed to accommodate the 5th percentile female astronaut and the 95th percentile female astronaut.

### U.S. LOCATIONS WORKING ON THIS PROJECT



■ U.S. States With Work      ★ **Lead Center:**  
Johnson Space Center

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## DETAILS FOR TECHNOLOGY 1

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### Technology Title

Load bearing Equipment for Bone and Muscle

### Technology Description

This technology is categorized as a hardware system for manned spaceflight

This technology advancement provides the high eccentric resistance loads needed to maintain bone and muscle during prolonged microgravity exposure. Back support and immediate human feedback when astronauts work together to provide resistance to each other increase safety. Adjustments and versatility to add elastic or springs from the frame to the shoe accommodate astronauts of various sizes and strengths. Simple design makes assembly and use rapid and storage compact. Shoulder pads and thoraco lumbar support orthoses provide comfort for heavy loads. The frame work allows prescribed motions to maintain load vectors correctly for bone while minimizing risk of injury from misapplied torques to joints. The overall design requires minimal upkeep and provides the type and magnitude of loads to maintain the musculoskeletal system as required for long duration space missions

### Capabilities Provided

The deliverable is a prototype exercise device and video demonstration of use of the device for squats can lead to testing on ISS. Testing in a full range of exercises is not easily achieved in earth gravity, but demonstration of squats with two test personnel lying on their sides and back to back should be possible. The load bearing equipment will provide a platform for exercises required for bone and muscle maintenance on missions over 30 days duration. Compact size, low mass, and reliability are achieved by having astronauts act as motors and controllers to apply exercise forces to each other. The frame controls motion to prevent accidental injury from force application in the wrong direction or from accidental kicking during exercise.

### Potential Applications

Further testing in neutral buoyancy can explore the various exercises possible. Strain gages linked between the overshoes and the cords can provide load information in future testing. Testing as a musculoskeletal disuse countermeasure on ISS will be proposed. The intended application is for missions over 30 days duration that require minimal added mass, such as exploration missions with a habitation module.

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### Performance Metrics

Metric	Unit	Quantity
Decrease mass compared to ISS ARED	%	94